BL31LEP
Laser–Electron Photon II

1. Introduction

BL31LEP (LEPS2 beamline) injects 355-nm UV-laser light to the 8-GeV electron storage ring to obtain a γ-ray beam (laser–electron photon) up to 2.4 GeV by backward Compton scattering between the laser photons and the electron beam. We deliver this γ-ray beam to the LEPS2 experimental building, which is located beyond the storage ring, irradiate γ-rays onto targets, and measure hadron photoproduction.

At the BL31LEP beamline, we have two separate experimental setups, one is BGOegg, which uses an electromagnetic calorimeter as the main detector, and the other is the solenoid spectrometer, which uses charged particle trackers as the main detectors.

In FY2020, results of ω meson photoproduction and the η' meson–nucleus bound state search using the BGOegg setup were published, and the detector for the solenoid spectrometer was developed. In the following sections, we report the activities related to these two experiments in FY2020.

2. Results of the BGOegg experiment

2-1. ω meson photoproduction

We measured differential cross sections, photon beam asymmetries, and spin density matrix elements for the ω meson photoproduction off the proton target to study unestablished nucleon resonances, which should appear in the s-channel [1]. The ω meson was identified by the decays $\omega \to \pi^0\gamma \to \gamma\gamma\gamma$, which were detected at the large-acceptance calorimeter BGOegg with the world's highest energy resolution. The photon beam asymmetries and spin density matrix elements were obtained from the distributions of ω or π^0 emission angles relative to the linear polarization direction of the photon beam. These polarization observables are sensitive to the existence of small resonance contributions via interferences. By using the high-quality beam, we obtained them for the first time in the photon beam energy range approximately above 2 GeV. Our new data is an important input into the precise partial wave analysis using overall photoproduction data, which will reveal high-spin nucleon resonances and lead to a better understanding of the hadron structure beyond the constituent quark model.

2-2. η' meson–nucleus bound state search

The mechanism of hadron mass generation is not well understood. η'(958) meson is one of the good probes used to examine the mechanism experimentally. A large mass reduction of η' meson in the nucleus is expected in several model calculations. If the η' meson mass is reduced in a nucleus, the η' meson and the nucleus may form a bound state. We searched for the η' meson–nucleus bound states by the missing-mass spectroscopy of the ^{12}C(γ, p) reaction [2]. Missing-mass spectroscopy around η' mesonmass suffers from numerous background events arising from multiple light-meson productions. Therefore, we tagged an η meson–proton pair, which is expected to be emitted during the η'N →ηN absorption of a bound η' meson in a nucleus. This was the first missing-mass spectroscopy around the η' meson production threshold coinciding with decay products. We optimized kinematical selection criteria of the (η+p) pair to reduce background events and to enhance signals from the η' meson–nucleus bound states. After the kinematical selections, no events were observed in the kinematical region of bound states. This result indicates a small branching fraction of the η'N →ηN process and/or a shallow η' meson-nucleus potential.

3. Status of development of the solenoid spectrometer

The solenoid spectrometer should support studies of exotic hadrons such as a pentaquark candidate composed of five quarks, meson–baryon–molecule candidates, and deeply bound antikaonic nuclei. For these experiments, a solenoid magnet of 3 m diameter and 1 T magnitude was shipped from Brookhaven National Laboratory in the United States. Currently, detectors that can detect both photons and charged particles are being developed.

The LEPS2 solenoid spectrometer consists of start counters (SCs), a time projection chamber (TPC), drift chambers (DCs), barrel resistive plate chambers (BRPCs), forward resistive plate chambers (FRPCs), barrel γ counters (Bγs), and aerogel Cherenkov counters (ACCs) (Fig. 1). The details of the LEPS2 solenoid spectrometer can be found elsewhere [3].

In FY2020, a spark-induced problem of TPC occurred, and we sent TPC to the company for repair. Thus, we tested detectors other than TPC. We adjusted the gain of photomultipliers of Bγs using the energy deposit information of charged particles using a photon beam. We also developed ACCs and installed them into the solenoid magnet. TPC was returned in March 2021, and we plan to resume test experiments from the 2021A cycle.

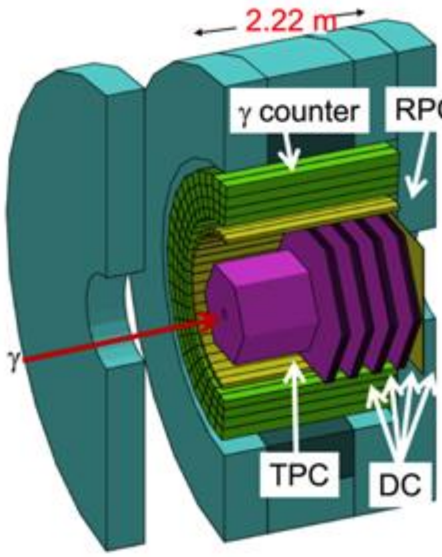

Fig. 1. Schematic of the LEPS2 solenoid spectrometer.

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